Ultrafast cavity switching :
A novel resource for solid-state CQED

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It is well known since the late 80’s that the optical modes and optical response of semiconductor microcavities can be changed in a transient and reversible way through a modification of the refractive index of the semiconductor matrix. Initially developed in view of all-optical data processing and computing, cavity switching induced by the electrical injection of free carriers is nowadays widely used for the reconfiguration of photonic circuits.

Cavity switching can also be used to tailor the spontaneous emission properties of embedded emitters, by enabling a dynamic control of the emitter-cavity mode detuning [1]. Recent theoretical advances show that single photons with a tailored time-envelope can be generated by a single quantum dot (QD) in a microcavity with a high efficiency and fidelity, by adjusting in real-time the magnitude of the Purcell effect [1,2]. This is noticeably the case for Gaussian time-envelopes and time reversed-exponential envelopes, both important resources for photonic quantum information processing. Kerr-switching on the sub-ps time scale [3] could also be used to control Rabi oscillations in strongly-coupled semiconductor systems.

We will also report recent switching experiments performed on micropillars containing collections of QDs. We observe large switching amplitudes (by as much as 20 linewidth), as well as differential switching of the pillar modes [4], using ultrafast optical carrier injection. Furthermore, cavity switching is applied for the first time to the generation of ultrashort pulses (down to 4ps!) of spontaneous emission. Unlike laser-based ones, these light pulses lack temporal coherence, which opens various application prospects such as speckle-free imaging.

References

1. H. Thyrrestrup at al, Opt. Exp. 21, 23130 (2013)
2. E. Peinke et al, submitted (2015)
3. H. Thyrrestrup et al, Appl. Phys. Lett. 105, 111115 (2014)
4. G. Ctistis et al, Appl. Phys. Lett. 98, 161114 (2011) and Appl. Phys. Lett. 99, 199901 (2011); E. Yüce et al, Opt. Lett. 38, 374 (2013)